

| T | Schemes | Applicability | Lookup Time | Memory | Update Time | Multicast |
|---|---------------|-------------------------------|------------------|--------|-------------|-----------|
| N | Patricia | 1st, 2nd upto Last Hop Router | $O(\log(n))$ | Low | Low | No |
| O | DP Trie | 1st, 2nd upto Last Hop Router | $O(\log(n))$ | Low | Low | No |
| N | LPCTrie | 1st, 2nd upto Last Hop Router | $O(\log^*(n))$ | High | Low | Yes |
| C | Lulea | 1st, 2nd upto Last Hop Router | $\ll O(\log(n))$ | Low | High | No |
| O | CAM | 1st, 2nd upto Last Hop Router | $O(1)$ | - | High | Yes |
| P | DRAM | 1st, 2nd upto Last Hop Router | $O(1)$ | High | High | No |
| C | Tag Switching | 2nd upto Last Hop Router | $O(1)$ | High | High | Yes |
| O | MPLS | 2nd upto Last Hop Router | $O(1)$ | High | High | Yes |
| P | IP Switching | 2nd upto Last Hop Router | $O(1)$ | High | High | Yes |
| H | CLUE | 2nd upto Last Hop Router | $O(1)$ | High | Low | No |

FIG. 3

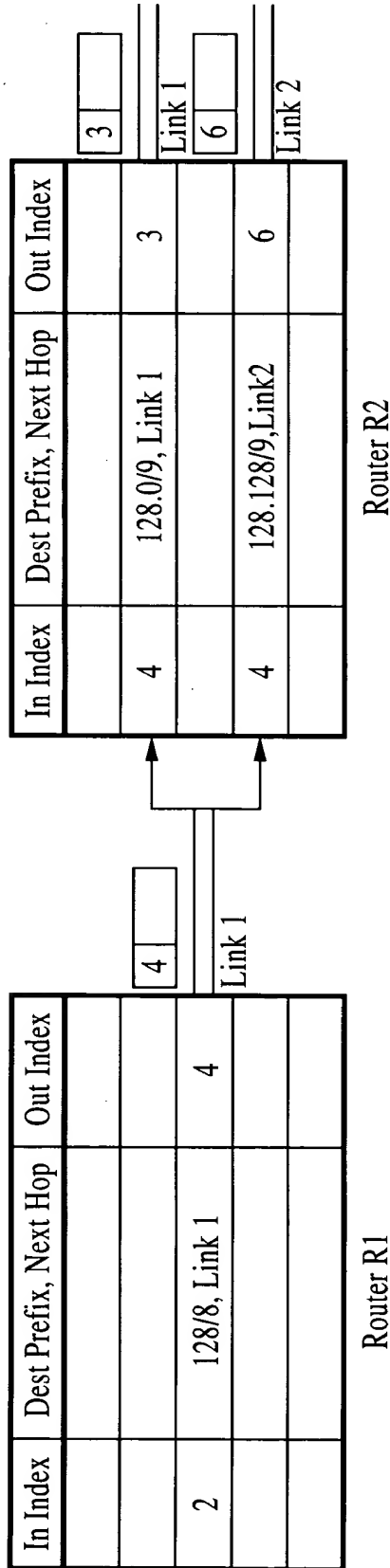


FIG. 4

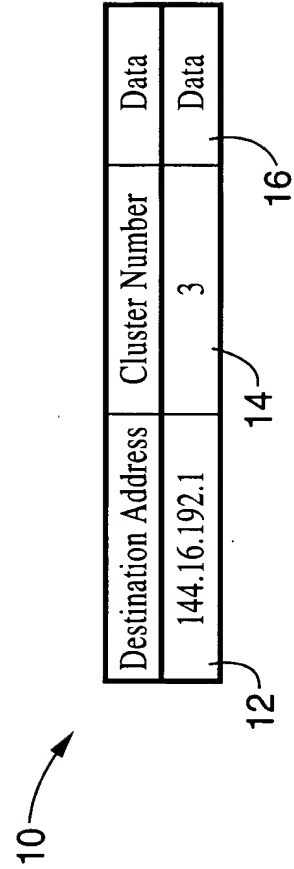


FIG. 5

4/28

FIG. 6

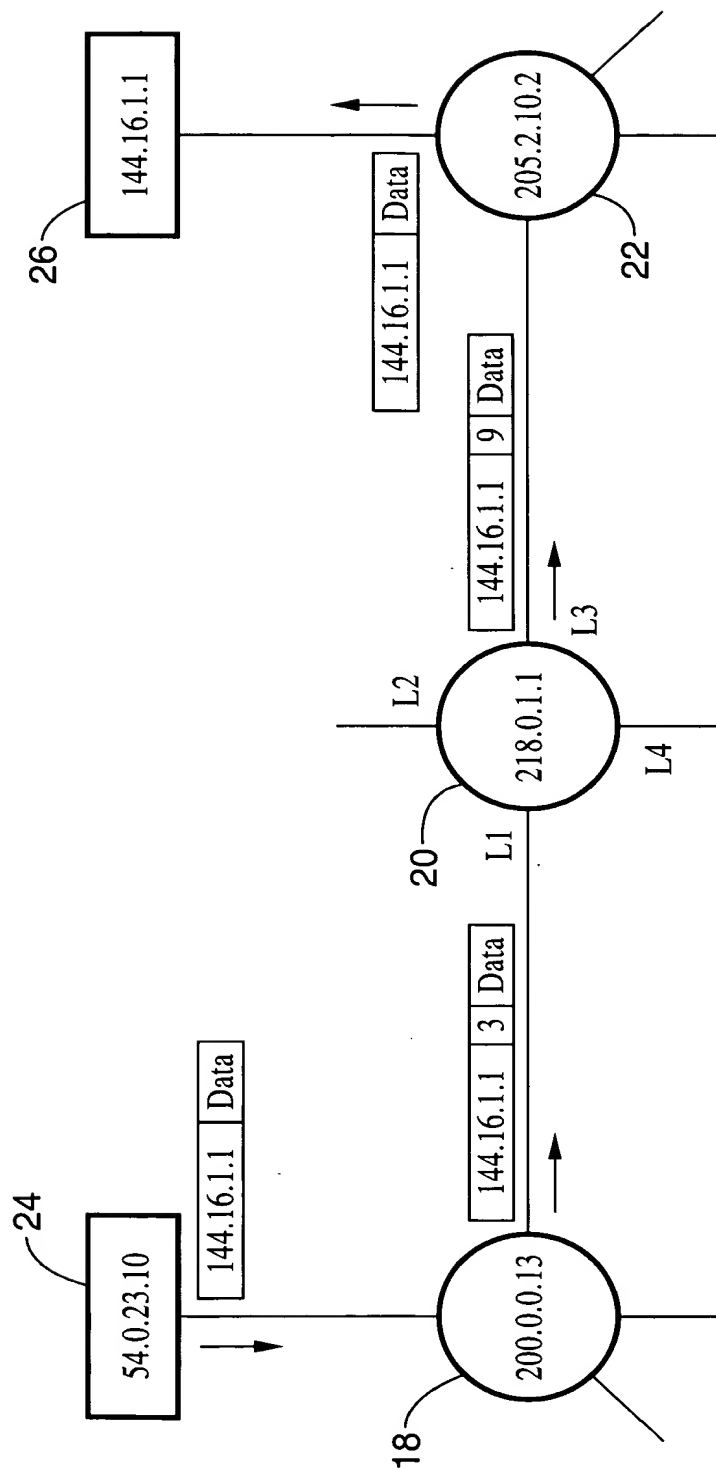


FIG. 6

FIG. 7

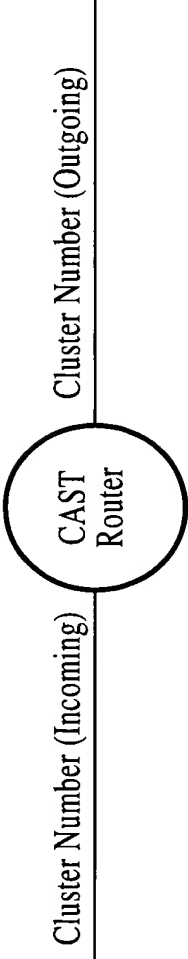


FIG. 7

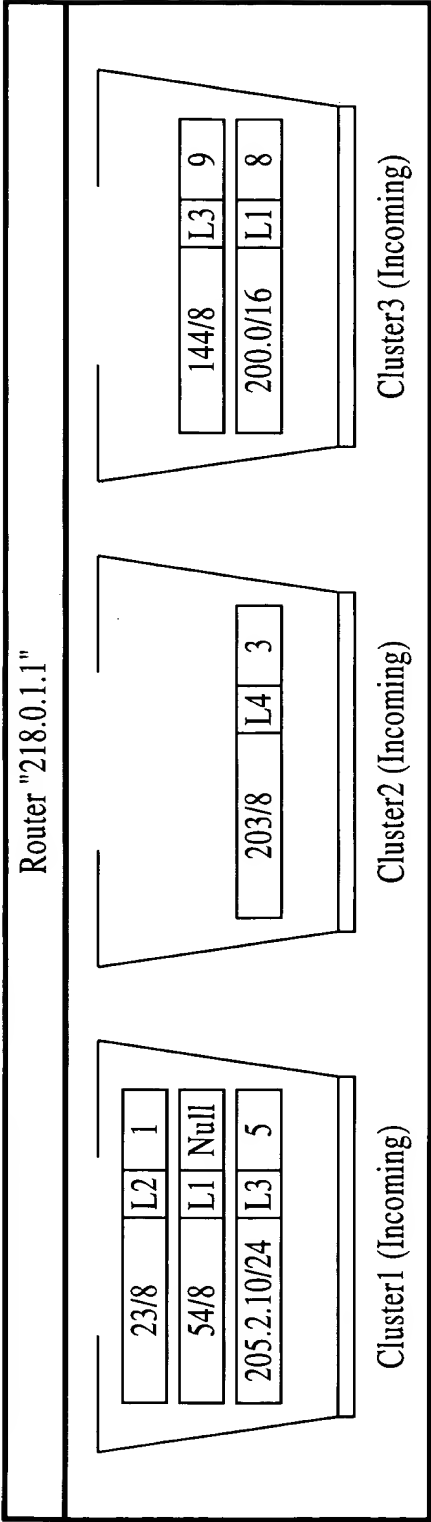


FIG. 8

| Prefix Entry | Next Hop Link | Cluster Number (Outgoing) |
|--------------|---------------|---------------------------|
| 144/8 | L3 | 9 |

FIG. 9

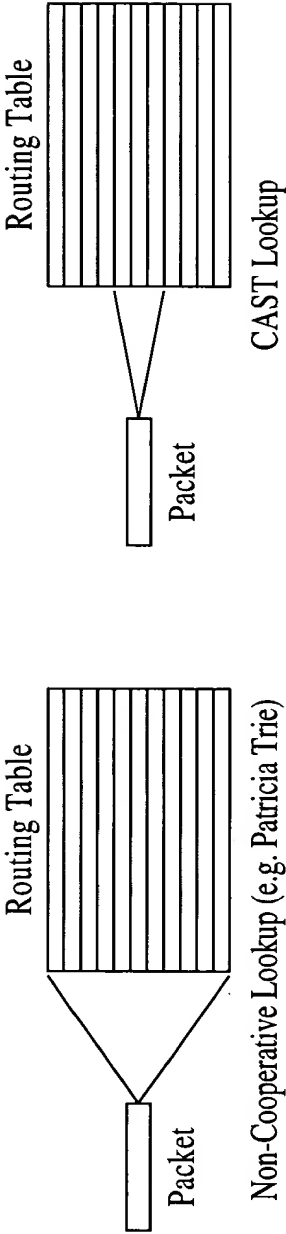


FIG. 10A

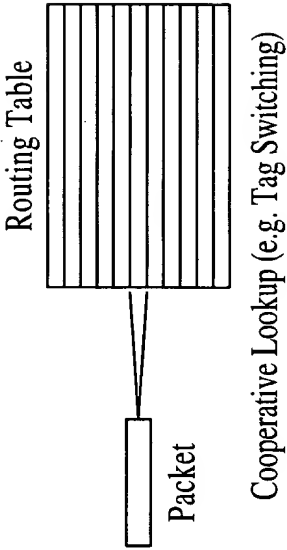


FIG. 10B

FIG. 10C

| Prefix | Next Hop Link | Cluster Number (Outgoing) |
|---------|---------------|---------------------------|
| 0000* | L2 | 2 |
| 00010* | L3 | 3 |
| 00011* | L2 | 2 |
| 1000* | L1 | 4 |
| 100100* | L2 | 1 |

FIG. 12

| Technique | Applicability |
|-----------|-------------------------------|
| Patricia | 2nd upto Last Hop Router |
| Symmetric | 1st, 2nd upto Last Hop Router |
| Link | 2nd upto Last Hop Router |

FIG. 11

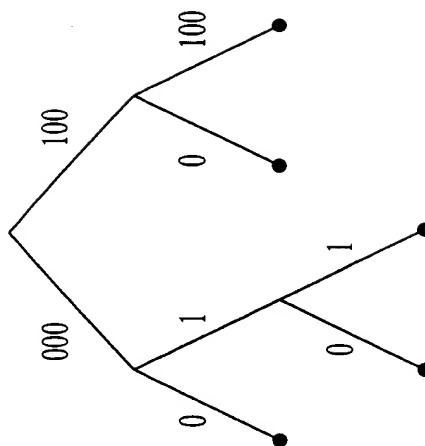


FIG. 13

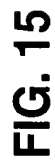


FIG. 14

9/28

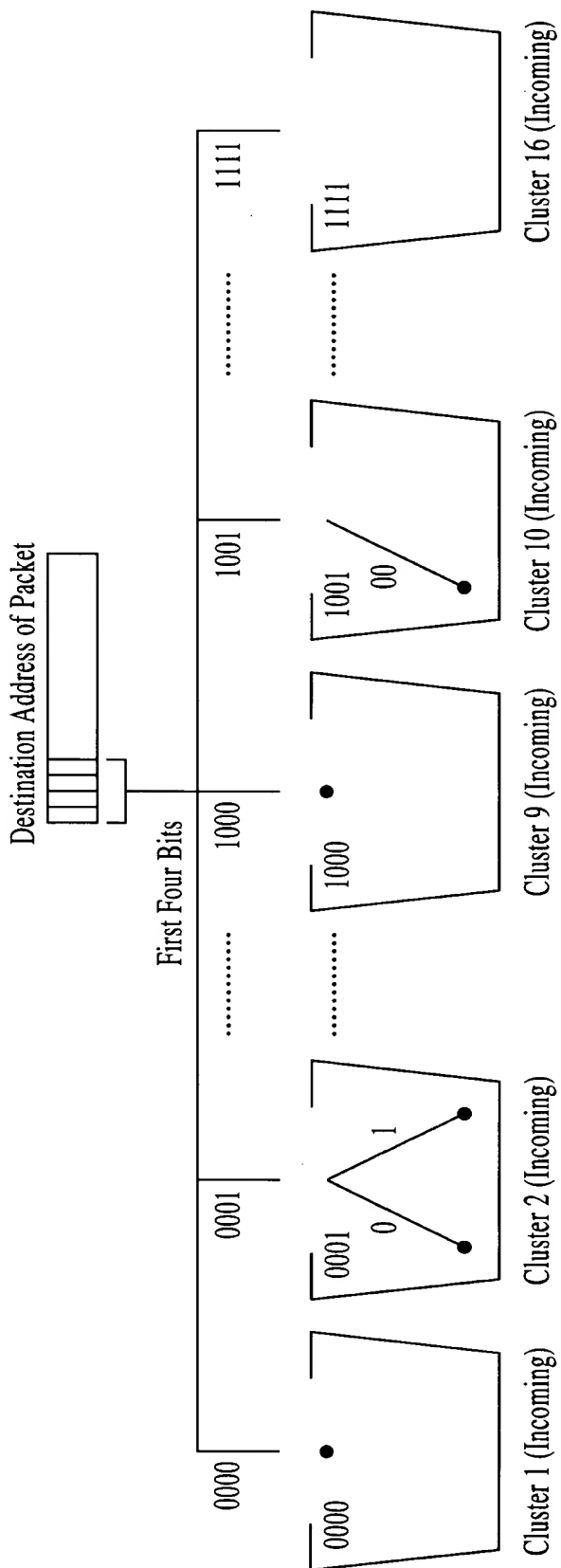


FIG. 16

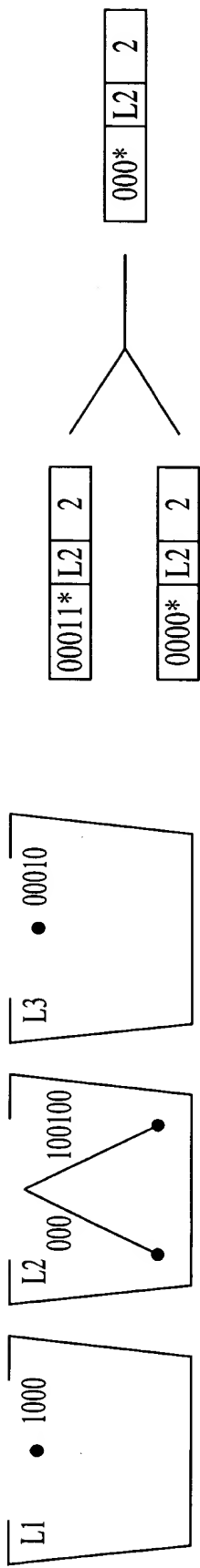


FIG. 18

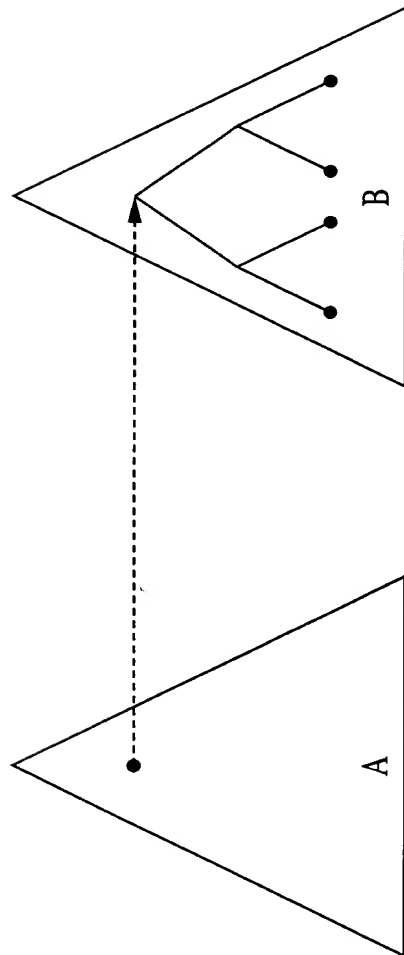


FIG. 19

DATA STRUCTURE

```

struct CAST_ROUTING_TABLE
{
    PREFIX_TABLE PT
    CONFLICT_TABLE CT
    CLUSTER_TABLE_INCOMING CTI
    CLUSTER_TABLE_OUTGOING CTO
    NEXTHOP_TABLE NT
}
    
```

FIG. 20A

11/28

TABLES

TABLES

| PREFIX TABLE | | | |
|--------------|--------|--------|--|
| CHILD | PREFIX | SKIP | POINTER (TO LEFT CHILD OR CLUSTER TABLE (OUTGOING) OR CONFLICT TABLE) |
| 1 bit | 1 bit | 5 bits | 17 bits |
| : | : | : | : |

| CONFLICT TABLE | |
|----------------------------|--|
| POINTER (TO LEFT CHILD) | POINTER (TO CLUSTER TABLE (OUTGOING)) |
| 15 bits | 17 bits |
| : | : |

| CLUSTER TABLE (INCOMING) |
|--------------------------|
| PATRICIA START LENGTH |
| : |
| 5 bits |

| CLUSTER TABLE (OUTGOING) | |
|---------------------------|-----------------------------|
| CLUSTER NUMBER (OUTGOING) | POINTER (TO NEXT HOP TABLE) |
| 17 bits | 7 bits |
| : | : |

| NEXTHOP TABLE |
|---------------|
| NEXTHOP |
| : |
| 32 bits |

FIG. 20B

| | | |
|-----------|-----------|----------|
| APPROVED | O.G. FIG. | |
| DY | CLASS | SUBCLASS |
| DRAFTSMAN | | |

12/28

FIG. 20C

```

Procedure: CAST_Forward_Packet(Packet packet)
Upon receiving an unicast packet this procedure is called in a CAST router
begin
  if((packet.cluster.no_incoming = 'Null') or packet.cluster.no_incoming doesn't exist) then
    cluster_no_symmetric ← Binary_to_decimal(packet.destination, symmetric_start_length)
    pointer_cluster_outgoing ← Search_prefix_table(cluster_no_symmetric, symmetric_start_length)
    cluster_no_outgoing ← CTO[pointer_cluster_outgoing].cluster_no_outgoing
    pointer_nexthop ← CTO[pointer_cluster_outgoing].pointer_nexthop
    nexthop ← NT[pointer_nexthop].nexthop
    Sendpacket (cluster_no_outgoing, nexthop)
  else
    patricia_start_length ← CTI[packet.cluster.no_incoming]
    pointer_cluster_outgoing ← Search_prefix_table(packet.cluster_no_incoming, patricia_start_length, packet.destination, PT, CT)
    cluster_no_outgoing ← CTO[pointer_cluster_outgoing].cluster_no_outgoing
    pointer_nexthop ← CTO[pointer_cluster_outgoing].pointer_nexthop
    nexthop ← NT[pointer_nexthop].nexthop
    Sendpacket (cluster_no_outgoing, nexthop)
  endif
end

```

FIG. 20C

FIG. 21A

DATA STRUCTURE

```
struct CAST_ROUTING_TABLE
{
    LINK_PREFIX_TABLE PT
    CONFLICT_TABLE CT
    CLUSTER_TABLE_INCOMING CTI
    CLUSTER_TABLE_OUTGOING CTO
}
```

FIG. 21A

TABLES

| CLUSTER TABLE (INCOMING) | |
|--------------------------|-----------------------------------|
| NEXTHOP | POINTER (TO LINK-PREFIX TABLE) |
| | |
| : | : |
| | |

32 bits 17 bits

| LINK-PREFIX TABLE | | |
|-------------------|--------|--|
| CHILD | PREFIX | SKIP POINTER (TO LEFT CHILD or CLUSTER TABLE (OUTGOING) or CONFLICT TABLE) |
| | | |
| : | : | : |
| | | |

1 bit 1 bit 5 bits 17 bits

| CONFLICT TABLE | |
|----------------------------|--|
| POINTER (TO LEFT CHILD) | POINTER (TO CLUSTER TABLE (OUTGOING)) |
| | |
| : | : |
| | |

15 bits 17 bits

| CLUSTER TABLE (OUTGOING) | |
|------------------------------|---|
| CLUSTER NUMBER (OUTGOING) | |
| | |
| : | : |
| | |

8 bits

FIG. 21B

| | | |
|-----------|-----------|----------|
| APPROVED | O.G. FIG. | |
| DY | CLASS | SUBCLASS |
| DRAFTSMAN | | |

14/28

ALGORITHM

Procedure: CAST_Forward_Packet(Packet packet)

Upon receiving an unicast packet this procedure is called in a CAST router

```

begin
  nexthop
  pointer_link-prefix_table
  pointer_cluster_outgoing
  cluster_no_outgoing
  Sendpacket (cluster_no_outgoing, nexthop)
  **Link Clustering**
  CTI[paket.cluster_no_incoming].nexthop
  ← CTI[pointer_cluster_outgoing].pointer_link-prefix_table
  ← Search_link-prefix_table(pointer_link-prefix_table, 0, paket.destination, PT, CT)
  ← CTO[pointer_cluster_outgoing].cluster_no_outgoing
end

```

FIG. 21C

Router A

| Multicast Group | Next Hop Links |
|-----------------|----------------|
| 224.1.2.1 | L1,L3 |
| 224.1.2.3 | L2 |
| 224.1.2.4 | L1,L3 |
| 224.1.2.8 | L3 |
| 224.1.2.9 | L2 |

Router B

| Multicast Group | Next Hop Links |
|-----------------|----------------|
| 224.1.2.3 | L2,L3 |
| 224.1.2.5 | L4 |
| 224.1.2.9 | L2,L3 |

FIG. 22

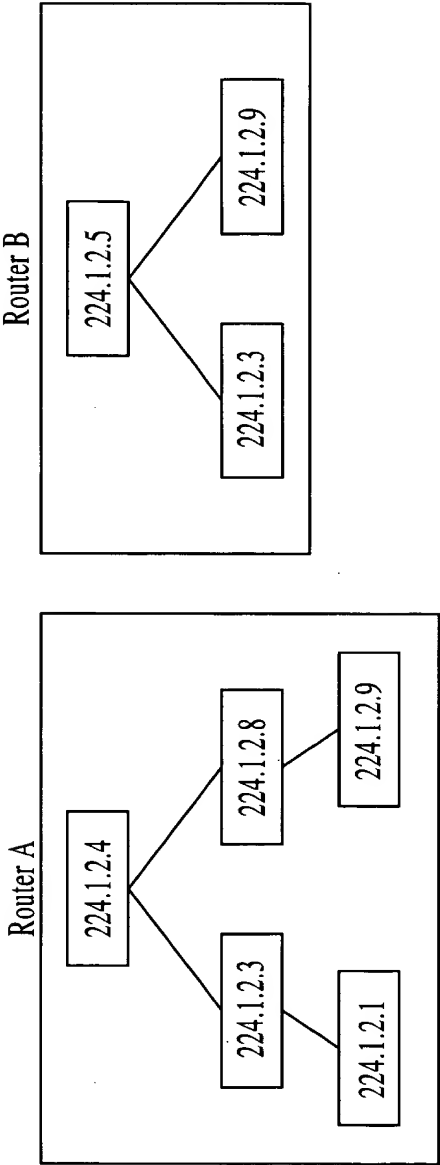
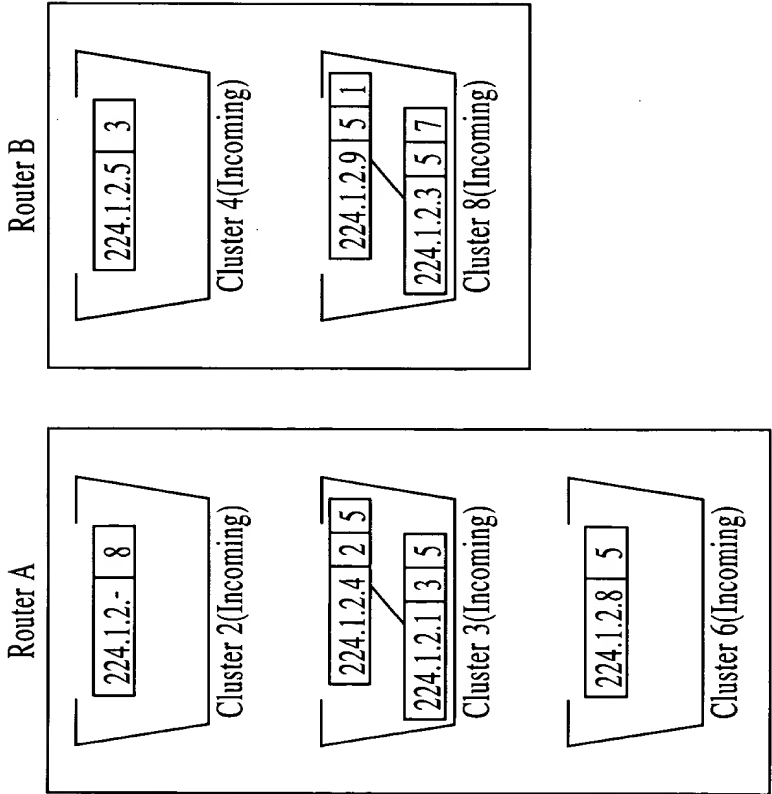


FIG. 23



| Outgoing Links | Cluster No. Incoming |
|----------------|----------------------|
| L1 | 1 |
| L2 | 2 |
| L3 | 3 |
| L1,L2 | 4 |
| L1,L3 | 5 |
| L2,L3 | 6 |

FIG. 25

FIG. 24

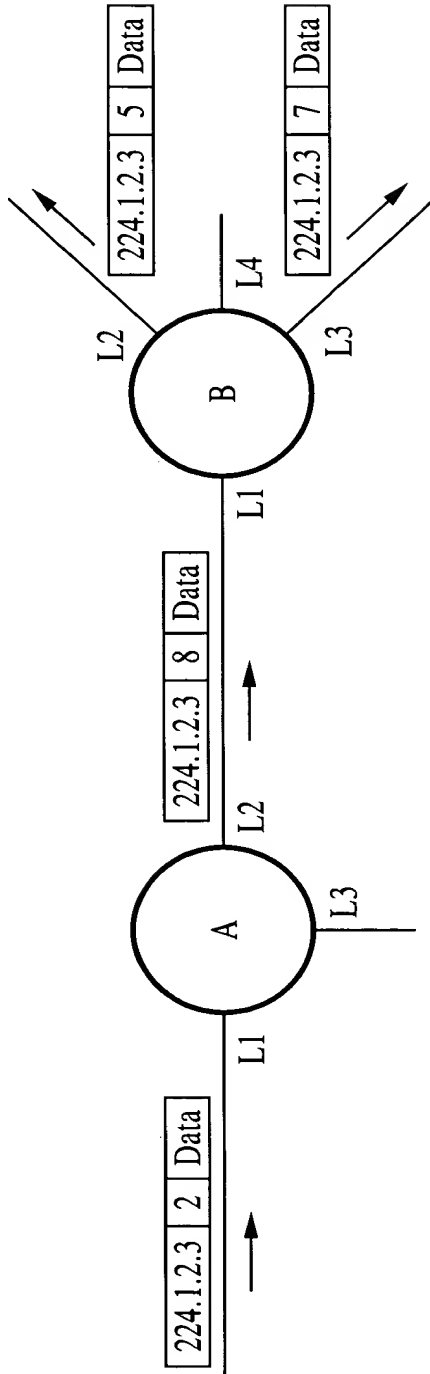


FIG. 26



FIG. 27

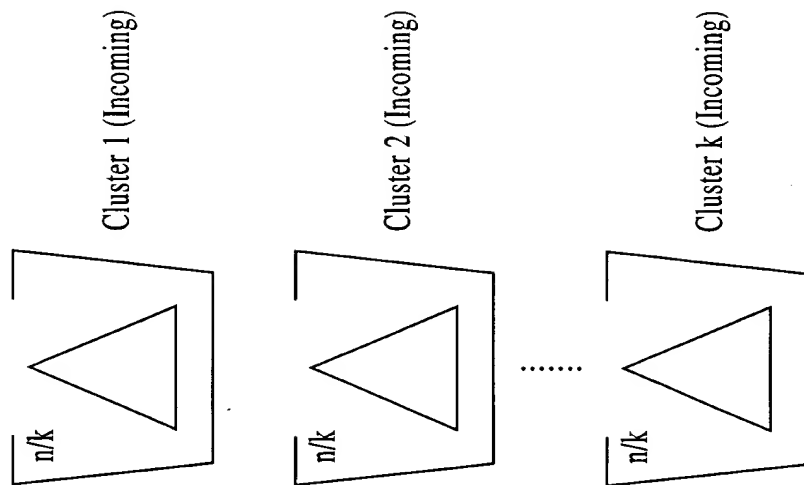


FIG. 30

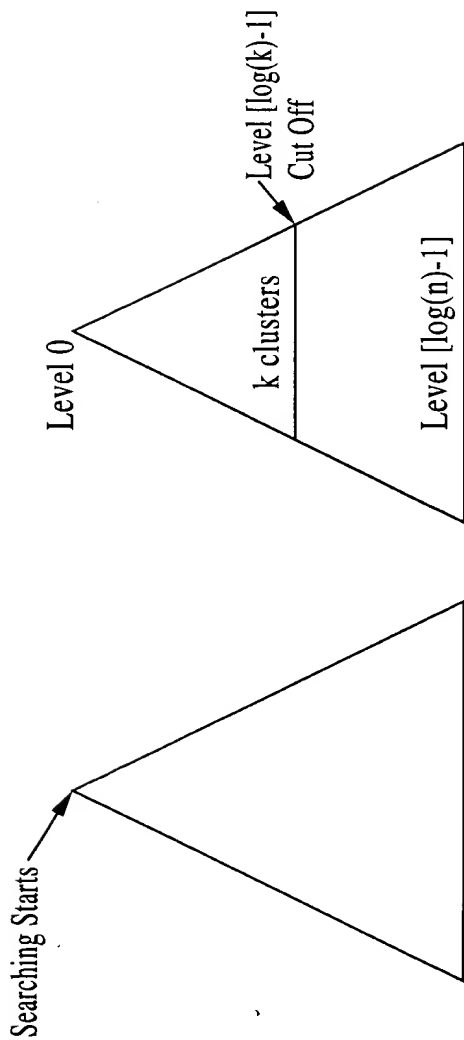


FIG. 29

FIG. 28

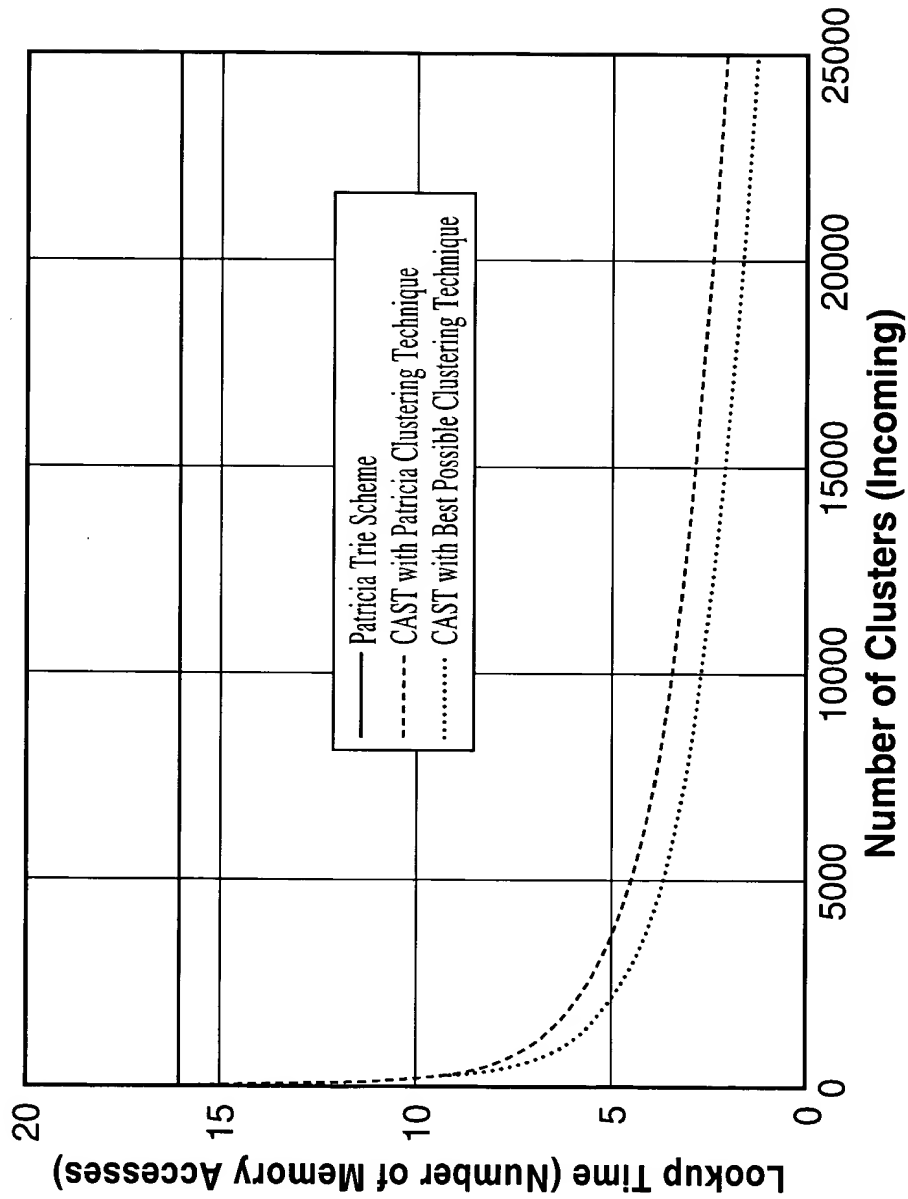


FIG. 31

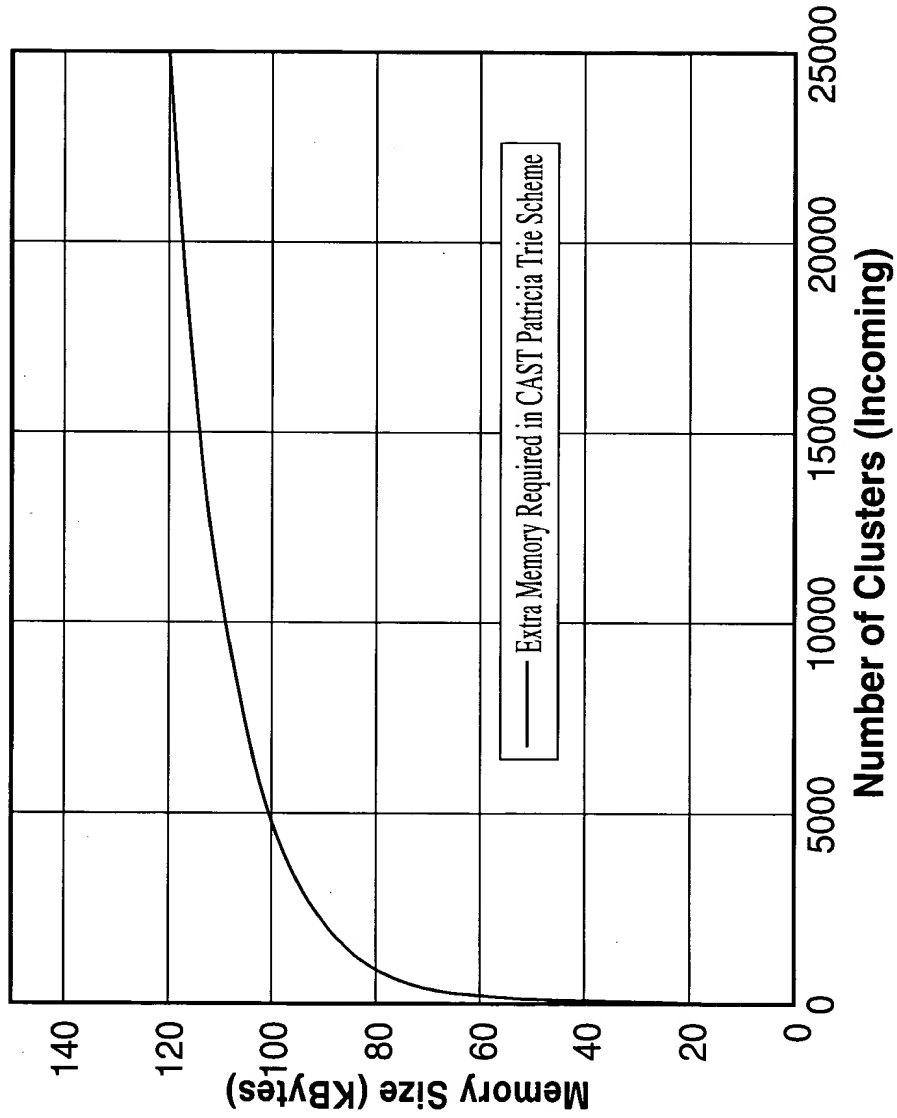


FIG. 32

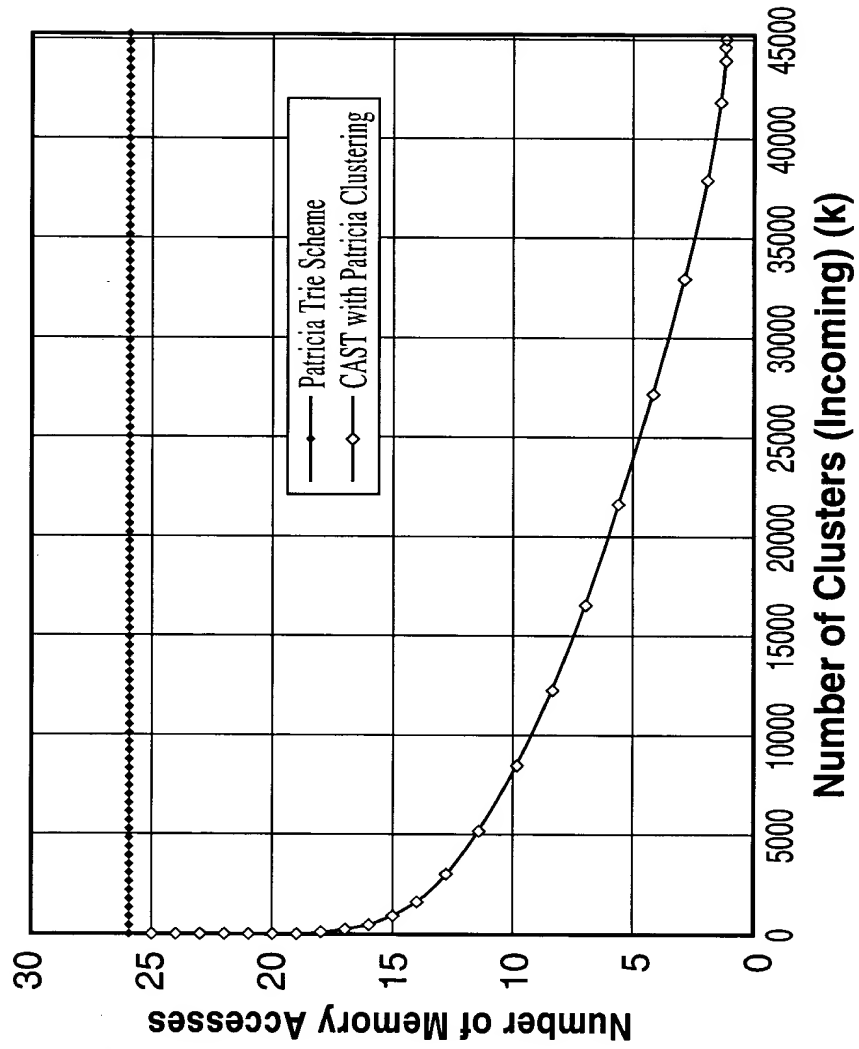


FIG. 33

22/28

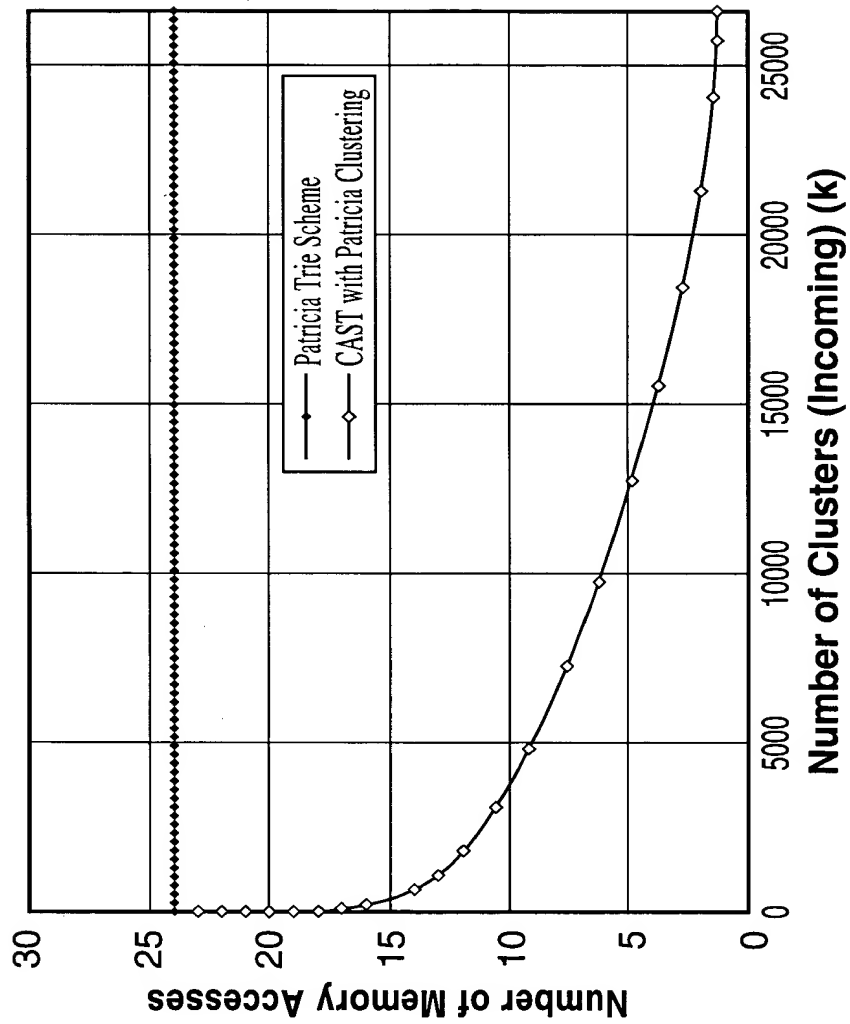


FIG. 34

FIG. 35

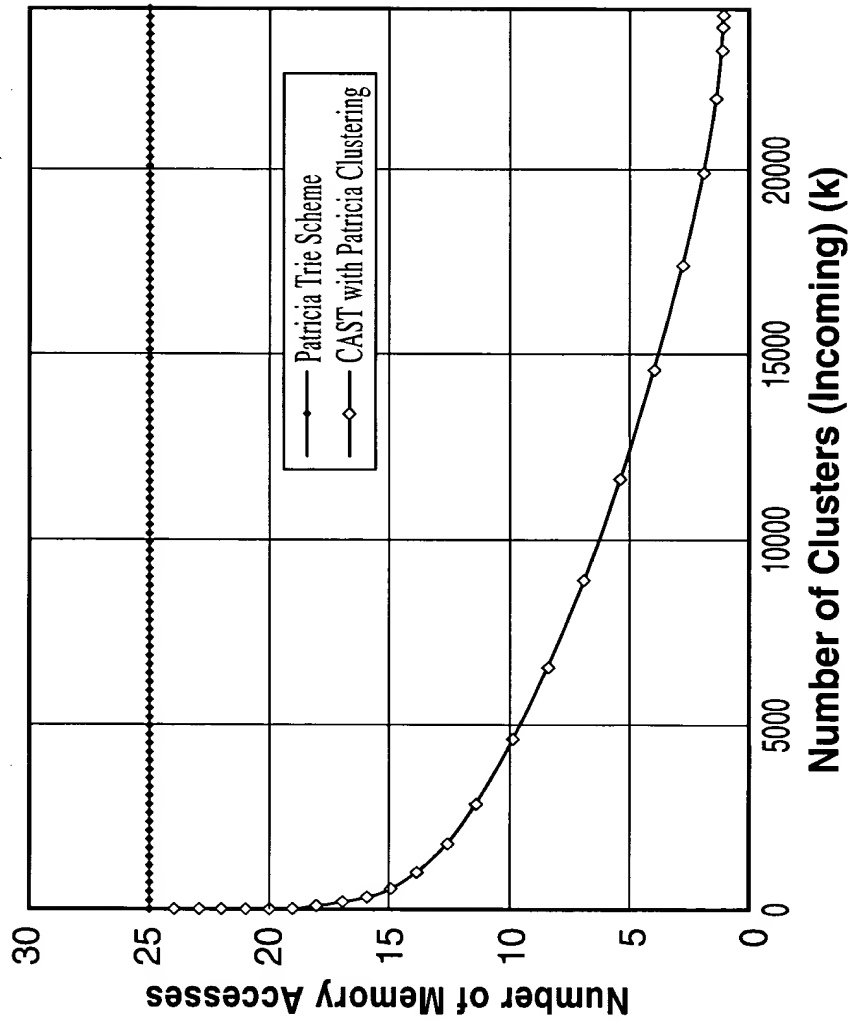


FIG. 35

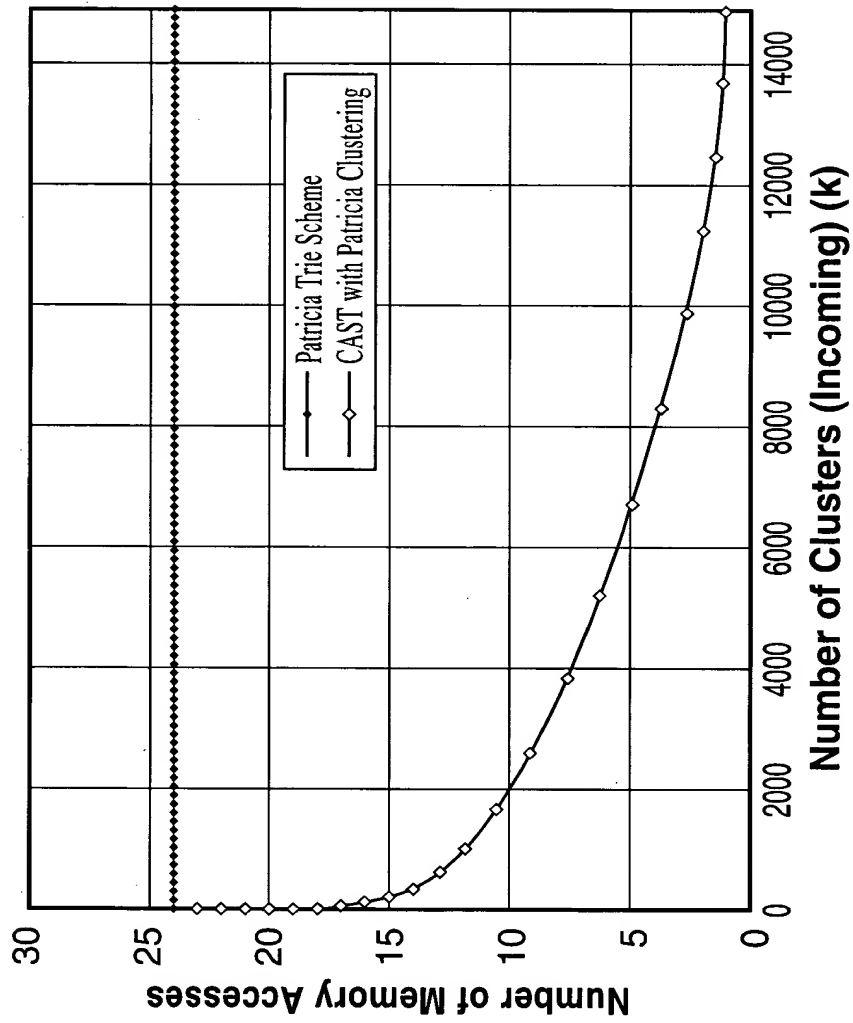


FIG. 36

FIG. 37

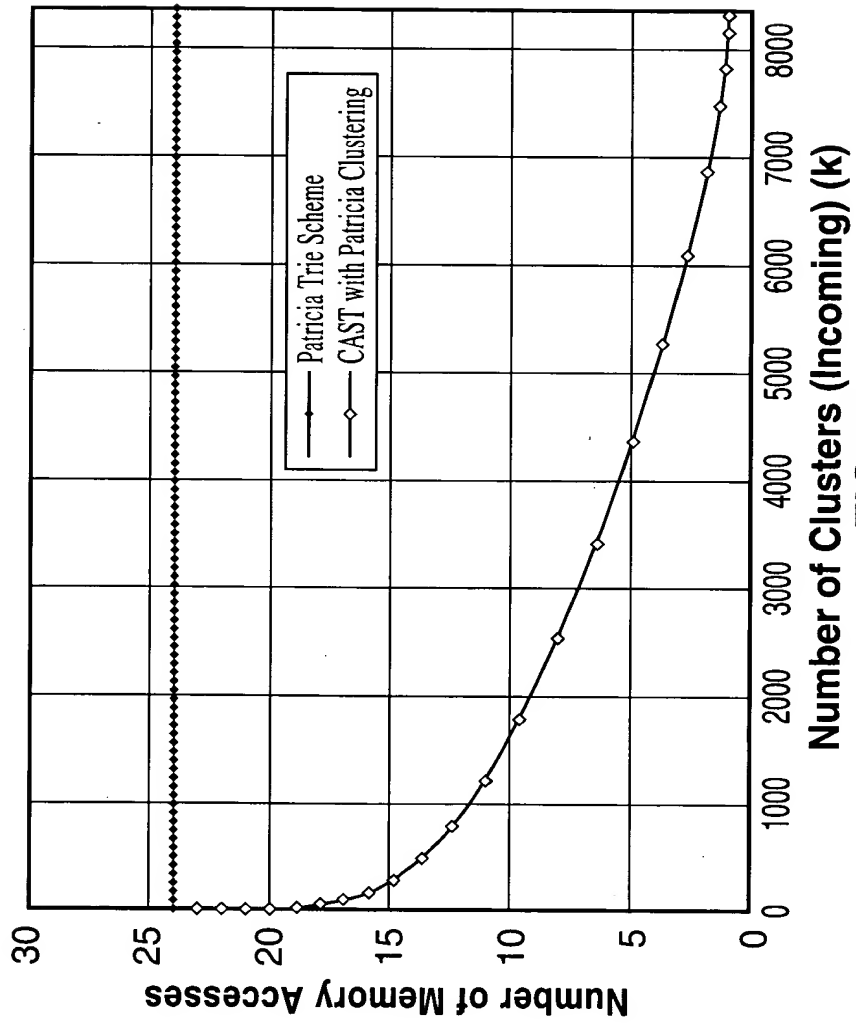


FIG. 37

| Actual Implementation Results | | | | | |
|-------------------------------|---------------------|----------|----------|------|------|
| Scheme | Lookup Power (MPPS) | | | | |
| | MAE-EAST | MAE-WEST | PAC-BELL | AADS | PAIX |
| Patricia Trie | 0.75 | 0.90 | 1.95 | 1.13 | 1.02 |
| LPC | 2.12 | 2.41 | 2.90 | 3.53 | 4.17 |
| CAST (Patricia) | 4.89 | 5.03 | 6.32 | 6.53 | 7.81 |
| CAST (Symmetric) | 0.92 | 1.07 | 2.19 | 1.26 | 1.25 |
| CAST (Link) | 0.96 | 1.11 | 2.20 | 1.27 | 1.27 |

FIG. 38

| Multicast Results (40,000 Entries) | | | | | |
|--|---------------------------|---------------------------|---------------------|-----------------|-------------------------------|
| Scheme | Lookup Power | | | Memory (KBytes) | Update Time (Memory Accesses) |
| | Maximum (Memory Accesses) | Average (Memory Accesses) | Lookup Power (MPPS) | | |
| AVL Tree | 16 | 15.21 | 1.31 | 1026 | 15.21 |
| Tag Switching | 1 | 1.00 | 20.00 | 1040 | 15.24 |
| IP Switching | 16 | 2.42 | 8.26 | 1862 | 30.43 |
| CAST (Link clustering, 2048 Clusters(In.)) | 7 | 4.17 | 23.98 | 889 | 15.18 |

FIG. 39

FIG. 40

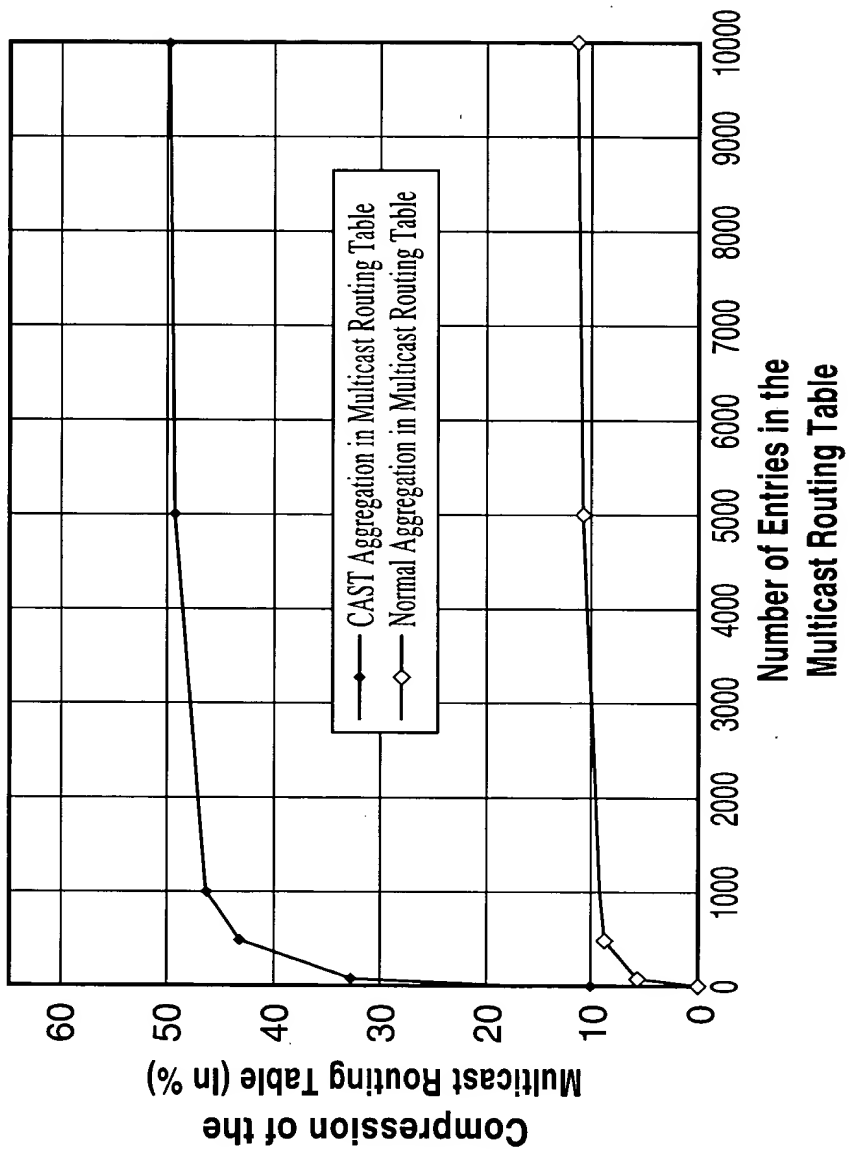


FIG. 40

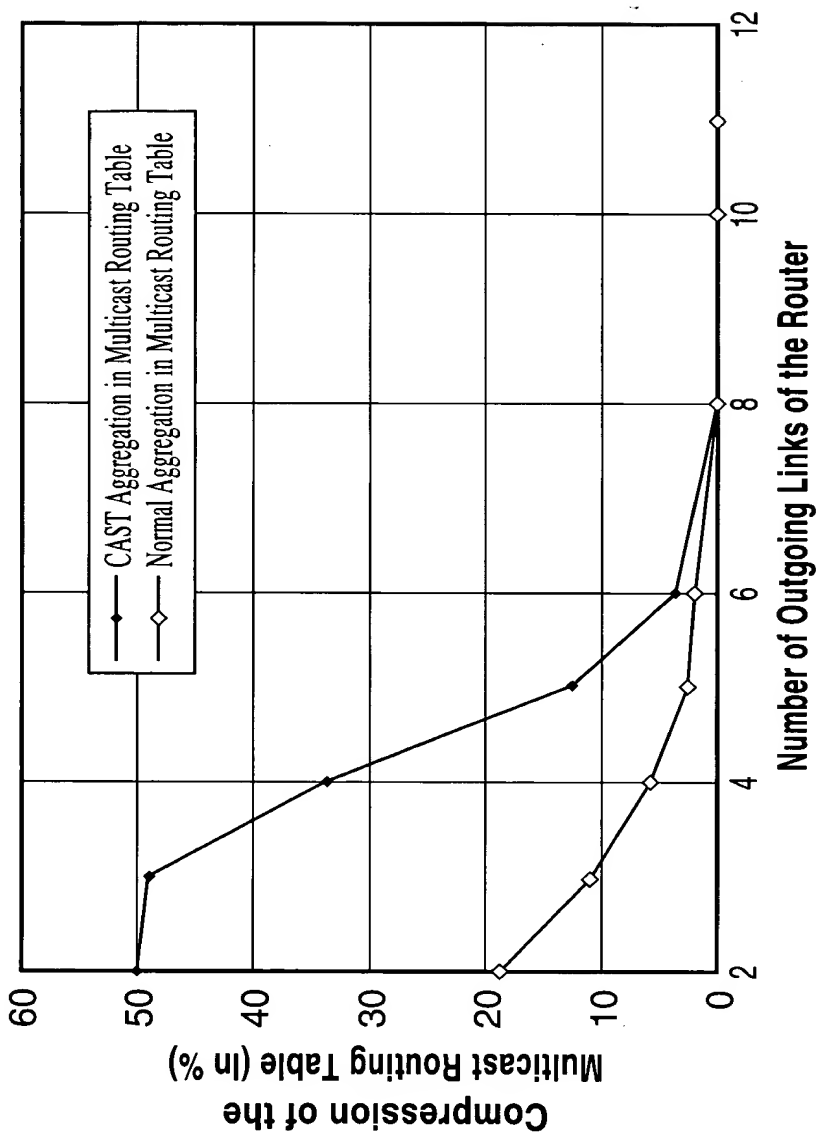


FIG. 41